UNITED
NATIONS

E

Economic and Social Council

Distr.
GENERAL

E/CN.17/IPF/1996/3
21 February 1996
ENGLISH
ORIGINAL: ENGLISH/FRENCH

COMMISSION ON SUSTAINABLE DEVELOPMENT
Ad Hoc Intergovernmental Panel on Forests
Second session
11-22 March 1996
Item 2 of the provisional agenda*

IMPLEMENTATION OF FOREST-RELATED DECISIONS OF THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT AT THE NATIONAL AND INTERNATIONAL LEVELS, INCLUDING AN EXAMINATION OF SECTORAL AND CROSS-SECTORAL LINKAGES

Programme element I.4: Fragile ecosystems affected by desertification, and the impact of air-borne pollution on forests

Report of the Secretary-General

SUMMARY

General

The present document reports on implementation of decisions of the United Nations Conference on Environment and Development related to the fourth programme element of category I, "Implementation of the United Nations Conference on Environment and Development decisions related to forests at the national and international level, including an examination of sectoral and cross-sectoral linkages", of the work programme of the Ad Hoc Intergovernmental Panel on Forests. It is presented in three parts. Part one deals with the experience with afforestation, reforestation and the restoration of forest systems, where appropriate, particularly in countries with fragile ecosystems and those affected by desertification and/or drought, particularly in Africa. Part two presents a synthesis of the impact of

* E/CN.17/IPF/1996/1.

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air-borne pollutants on forests, in particular those in Central and Eastern Europe. It includes a general overview of the issue, and a short update of the current status, and is followed by a description of the range of considerations for the substantive discussion of this programme element at the second session of the An Hoc Intergovernmental Panel on Forests. Part three suggests items to be discussed by the Panel.

Part one: Fragile ecosystems affected by desertification: monitoring actions to support afforestation, reforestation and the restoration of forest systems, particularly in Africa

The earth's fragile ecosystems, which are situated mainly in arid, semi-arid and dry sub-humid regions, are most affected by these phenomena, which are largely due to: (a) the population pressure associated with poverty and the resulting efforts to produce more food crops from less and less suitable soils; (b) inappropriate methods of developing forestry resources and grazing lands; (c) the impact of man-made or natural catastrophes, such as forest and brush fires, insect plagues, diseases and frequent, prolonged droughts.

The development of the forestry sector over the past 20 years, particularly in the countries with less forestry resources and the arid countries, has resulted in a form of forestry which is more open and responsive to the needs of populations and to the multi-purpose use of trees and forests in the different natural or man-made systems.

The general information section focuses on the need for reforestation because of land degradation, a process which is described and explained and whose consequences are analysed.

The section on current status focuses on poverty and its constituent elements, namely, unemployment (including or resulting from the scarcity of land in rural areas) and the lack of food security. The need for firewood, which represents the only available source of energy for the poorest groups, generally exceeds the production capacities of rural woodlands. These factors lead to strong pressure on tree and forest resources. The resulting deforestation is analysed; it strongly affects arid regions, particularly in the drylands of tropical Africa, where 2.22 million hectares are lost each year. Afforestation and reforestation can offer solutions to these problems, but the results to date have been poor, particularly in Africa, where the ratio of afforested/reforested to deforested areas is only 1 to 32; the conditions under which afforestation and reforestation are conducted, from the planning stages to the enjoyment of the goods and services which they provide, are still far from being satisfactory.

The report indicates numerous gaps and areas in which improvement is needed. Those which are of particular importance from the policy standpoint include: (i) the need to recognize both the potential and the limitations of afforestation and reforestation and to plan such programmes against a

background of sustainable development, particularly in rural areas; (ii) the need to plan afforestation and reforestation programmes in close collaboration with and with the participation of the populations concerned; (iii) the promotion of technologies and species that are both suited and familiar to the populations; (iv) the integration of tree planting into conservation programmes, particularly those concerned with the conservation of biodiversity, with all the related considerations regarding reforestation options as opposed to the management of natural stands, and choice of local species.

Part two: The impact of air-borne pollution on forests, particularly in Central and Eastern Europe

Forest declines and dieback of trees occur as a world-wide phenomenon. In addition to being widespread geographically, forest declines can be caused both by natural factors and by human influences. Indeed forest dieback may be part of a normal ecological succession. Human activities that can contribute to forest decline include pollutant depositions, overgrazing when woodlands are used for pastoral purposes, insensitive harvesting operations, use of plantations with low genetic diversity, accidental introduction of pest species, fire, alteration of hydrology and, finally, anticipated climate change associated with the burning of fossil fuels and increased concentration of greenhouse gases.

In the late 1970s and early 1980s, public attention was drawn to the deterioration of forest condition in Germany and subsequently in some other European countries and in parts of North America. By the early 1980s, these symptoms seemed to be widespread and public concern focused on whether such declines were new and pollutant-related. The terms "Waldsterben" and "neuartige Waldschaden" meaning "forest death" and "new-type forest decline" respectively were introduced and there was fear that the deterioration was irreversible.

Recent inventories show roughly stable levels of emission of nitrogen oxides from European countries between 1980 and 1993, and a moderate decrease in ammonia emissions from 7,649 thousand tons per annum in 1980 to 6,573 thousand tons per annum in 1993.

It is clear that the Central European area which includes areas of Poland, the former German Democratic Republic (East Germany), the Czech Republic and Slovakia have the largest proportion of defoliated trees. This is the area of Europe that has been referred to as "the black triangle"; in this area there have been large sulphur emissions from heavy industry and the combustion of high-sulphur-content coal.

The International Institute for Applied Systems Analysis has recently undertaken a study of forest resources of Western and Eastern Europe with the objectives of looking at the potential developments of the forest resource, illustrating the effects of forest decline caused by air pollutants on this resource and identifying policy options for dealing with these effects. The

study represents a unique attempt to provide predictions on the way in which sulphur and nitrogen depositions might affect the development of forest resources and of wood supply in Europe. The results are of considerable interest and indicate the importance for European countries of formulating new forestry policies to address the new conditions caused by the decline if they are to maintain current forest resources.

The concern over a single novel forest decline throughout Europe undoubtedly resulted from misinterpretation of the results of forest condition data (Forest Health Surveys), combined with lack of awareness of historical records of forest declines and lack of understanding of forest science, particularly nutrient-cycling and forest pathology. It is now clear that many of the statements that were made concerning the effects of pollutant deposition were appropriate on the local scale only.

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INTRODUCTION

1. The present document reports on implementation of the decisions of the United Nations Conference on Environment and Development related to the fourth programme element of category I, "Implementation of the United Nations Conference on Environment and Development decisions related to forests at the national and international level, including an examination of sectoral and cross-sectoral linkages", of the work programme of the Ad Hoc Intergovernmental Panel on Forests. It is presented in two parts. Part one deals with the experience with afforestation, reforestation and the restoration of forest systems, where appropriate, particularly in countries with fragile ecosystems and those affected by desertification and/or drought, particularly in Africa. Part two presents a synthesis of the impact of air-borne pollutants on forests, in particular those in Central and Eastern Europe. It includes a general overview of the issue and a short update of current status, and is followed by a description of the range of considerations for the substantive discussion of this programme element at the second session of the Panel.

2. The work under this programme element (I.4) is guided by the decisions taken at the third session of the Commission on Sustainable Development and further elaborated at the first session of the Ad Hoc Intergovernmental Panel on Forests.

3. The Commission on Sustainable Development, at its third session, defined programme element I.4 as a need to "monitor actions to support afforestation, reforestation and the restoration of forest systems, where appropriate, particularly in countries with fragile ecosystems and affected by desertification and/or drought, particularly in Africa. Within this context, also consider specific actions in countries whose forests are affected by pollution, particularly those with economies in transition in Central and Eastern Europe". 1/

4. Subsequently, the Panel, at its first session, emphasized the need for "a report on the experience with afforestation, reforestation and the restoration of forest systems, where appropriate, particularly in countries with fragile ecosystems and those affected by desertification and/or drought, particularly in Africa, including links to the implementation of the United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa. A synthesis of the impact of air-borne pollutants on forests - in particular, those in Central and Eastern Europe - and an assessment of ongoing activities and proposals for an assessment of the expansion of all types of forest cover due to reforestation and afforestation". 2/ At the first session of the Panel, it was decided to schedule programme element I.4 for substantive discussion at the Panel's second session, to be held in Geneva (11-22 March 1996).

5. The present report was prepared by the Food and Agriculture Organization of the United Nations (FAO), as lead agency for programme element I.4, in consultation with the secretariat of the Ad Hoc Intergovernmental Panel on Forests in the Division for Sustainable Development of the Department for Policy Coordination and Sustainable Development of the United Nations Secretariat. In

addition, contributions and comments were received from the Forestry Commission of the United Kingdom of Great Britain and Northern Ireland, from the Centre for International Forestry Research (CIFOR) and from the Global Forestry Policy Project. Part one is based on the report of a consultant in French and part two on the report of a consultant in English. Both reports contain valuable information that could not, however, be accommodated within the limits of a report of the Secretary-General, but will be available as regards consultation to support follow-up activities related to this programme element.

PART ONE. FRAGILE ECOSYSTEMS AFFECTED BY DESERTIFICATION: MONITORING ACTIONS TO SUPPORT AFFORESTATION, REFORESTATION AND THE RESTORATION OF FOREST SYSTEMS, PARTICULARLY IN AFRICA

I. INTRODUCTION

6. "The impacts of loss and degradation of forests are in the form of soil erosion, loss of biological diversity, damage to wildlife habitats and degradation of watershed areas, deterioration of the quality of life and reduction of the options for development." 3/ This is the conclusion contained in chapter 11 of Agenda 21.

7. The earth's fragile ecosystems, which are situated mainly in arid, semi-arid and dry sub-humid regions, are most affected by these phenomena, which are largely due to: (a) the population pressure associated with poverty and the resulting efforts to produce more food crops from less and less suitable soils; (b) inappropriate methods of developing forestry resources and grazing lands; (c) the impact of man-made or natural catastrophes, such as forest and brush fires, insect plagues, diseases and frequent, prolonged droughts.

8. The development of the forestry sector over the past 20 years, particularly in the countries with less forest resources and the arid countries, has resulted in a form of forestry which is more open and responsive to the needs of populations and to the multi-purpose use of trees and forests in the different natural or man-made systems.

II. GENERAL INFORMATION

A. Objectives of the study

9. This part contains a synthesis of part one of programme element 1.4 of the programme of work approved by the Commission on Sustainable Development for the open-ended Intergovernmental Panel on Forests. The document focuses on afforestation and reforestation programmes and their various functions. To this end, it recalls facts relating to degradation, studies the role of afforestation and reforestation in preventing and combating desertification, highlights gaps in knowledge, describes the experience gained and lessons learned and, lastly, identifies the challenges and the priorities for the future and proposes a list of priority actions which are of common interest to all the countries concerned.

B. Description of the problem

Elements and processes of desertification

10. Many civilizations have foundered as a result of their failure to control the population growth that is responsible for disrupting the balance between the degree of pressure (human and animal) placed on the land and the latter's capacity to absorb it. The traditional users of arid lands succeeded in developing land-use systems that were sustainable and compatible with their environment because they were careful to renew the fertility of the soils, their land-use options were characterized by flexibility and solidarity, and their land occupation density was low.

11. The considerable increase in population has changed the parameters without any corresponding change in the traditional systems of production so as to increase production on a sustainable basis. The constraints resulting from the increasing need to exploit resources and the reduction in the amount of available land have led to expansion towards forested and marginal areas and to competition which has spurred the widespread conduct of mining operations on lands that are now undergoing increasing degradation.

12. Sustainability of production, whether in agriculture, cattle farming, firewood or any other sector, depends on agrarian land-use systems capable of maintaining soil fertility and reducing all forms of land degradation. The vulnerability of land, however, is an additional constraint to sustainable exploitation, since the risk of desertification may increase, above all in a period of climate change and particularly in regions where poverty is endemic. Degradation and desertification may be brought about by inappropriate land-use systems or by a combination of the latter with recurrent drought at frequent intervals.

13. The expansion of agricultural zones is without doubt the main cause of deforestation in tropical drylands and in the Middle East. Reforestation, when integrated into forest management as an alternative to natural regeneration, can contribute to the conservation and development of forests.

Measures to combat desertification

14. In combating desertification, each type of landscape and each system of land use requires a different approach. There are, however, certain common measures that are prerequisites for the conservation and restoration of land in dry areas. These include:

(a) Adopting appropriate policies and legislative measures;

(b) Making an inventory of land resources and identifying both their potential and the constraints on their use;

(c) Choosing suitable approaches to sustainable development;

(d) Improving land-use methods and developing appropriate technologies;

(e) Ensuring user participation in all stages of planning and execution;

(f) Conducting research in rural areas;

(g) Training of managers and rural dwellers;

(h) Introducing incentive measures (price of agricultural and forest products, markets, subsidies, taxes, and so on) to encourage land users to adopt sustainable land-use methods;

(i) Diversifying employment, and so on.

The technical measures proposed below are general in nature and concern the principal uses of rural drylands as described above.

The economy and the role of reforestation in combating land degradation

15. Tree planting in various forms can constitute an effective means of combating soil degradation and, more particularly, desertification. In arid zones, trees are planted for the following reasons:

(a) To protect and maintain the balance within production systems. Trees and forests are critical to the preservation of the ecological and biological functions required for sustainable agricultural production. They help to preserve and improve soil productivity;

(b) To satisfy social and economic needs. Forests and trees constitute an important resource base which is essential to sustainable social and economic development, inasmuch as they provide a wide range of wood and non-wood products and services;

(c) To protect the habitat and to provide aesthetic value and shade. This function of trees has to do with enhancing living space, providing greater comfort for people and protecting human settlements. Significant progress has been made in this area in arid countries, and particularly in the Sudano-Sahelian region of Africa;

(d) To produce cattle fodder. Cattle raising in arid zones depends for a part of the year on wooded areas in the form either of fallow land, in the case of sedentary farming, or of fallow land and forests, in the case of transhumant cattle farming. In the Sahelian region, food for cattle consists on average of 25 per cent aerial fodder (up to 45 per cent at the end of the dry season). In the driest areas of the Brazilian savannah, aerial fodder accounts for 60 per cent of cattle food.

Evolution of the concept of the role of reforestation

16. There has been a considerable evolution in the concept of the role played by reforestation in the forestry industries of all continents, particularly in dry regions. In the past, forestry experts often tended to conduct reforestation as a means of demonstrating its technical potential. Gradually, however, efforts to meet needs for firewood, construction wood and utility wood

also came to be emphasized. In addition, protection of the environment and improvement of the habitat, and nowadays respect for and conservation of biological diversity, are becoming increasingly important in the design and planning of afforestation and reforestation projects.

III. CURRENT STATUS

Scope and impact of the problems

17. According to 1992 estimates by the Food and Agriculture Organization of the United Nations (FAO), nearly 500 million people, including 50 million cattle farmers, live in the drylands (annual rainfall of under 500 millimetres (mm) - period of growth less than 120 days per year) and regions characterized by uncertain rainfall (including sub-humid zones with light and irregular rainfall) which cover 20 million square kilometres of the earth's surface. These regions are also affected by severe degradation of resources, particularly through water and wind erosion: 60,000 square kilometres of land are lost each year.

18. The African continent is particularly affected, as a result of several factors which include:

(a) A large proportion of arid land (65 per cent of the continent);

(b) Strong population pressure relative to the productive capacity of the land;

(c) A combination of socio-economic problems and frequent institutional deficiencies;

(d) Consequently, a large proportion of affected land.

19. According to an assessment carried out in 1992 by the United Nations Environment Programme (UNEP), 74 per cent of the arable land in Africa is affected by various forms of deterioration. Seventy-three per cent of grazing land, 61 per cent of rain-fed agricultural land and 18 per cent of irrigated land on the African continent are undergoing desertification and, according to the assessment, have already lost 25 per cent of their fertility.

Reforestation as a response to deforestation

20. Reforestation campaigns over the last 10 years have been evaluated within the framework of the 1990 assessment of forest resources (FAO Forestry Paper No. 128, 1995). Plantations in countries located in the arid regions have most often been devoted to the production of firewood and, in the wettest regions, construction and utility wood. The goals of environmental preservation and desertification control have gained importance since the 1970s, but their vagueness, together with relatively lax planning and, often, a governmental approach to their establishment, have affected their sustainability.

21. It is impossible to overemphasize the difficulty and hazards of assessing man-made forests; it would seem simple to monitor plantations, but the difficulties are numerous. These difficulties include the following:

(a) Plantations have not in all cases been well planned;

(b) In cases when planting is unsuccessful, reuse of the same land compromises assessments based on field reports;

(c) Assessment methods vary widely from one country to another;

(d) The use of variable conversion factors when estimates of surface area are made a posteriori, on the basis of the number of trees planted, introduces other uncertainties.

Reforestation campaigns in tropical regions (in estimated net surface area)

22. In tropical countries, which accounted for approximately 17.5 million hectares of man-made forests in 1980, those areas have increased by 150 per cent to a total of 43.9 million hectares in 1990, with an average annual growth rate of 2.6 million hectares. In the breakdown of reforested land by major geographical region, tropical Africa accounts for only 7 per cent of planted areas, whereas tropical America accounts for 20 per cent and the Asian and Pacific region 73 per cent of such areas.

The evolution of reforestation campaigns in tropical Africa

23. From 1960 to 1980, African forestry services made major efforts at reforestation, with the help of outside financing. From 1961 to 1975, priority was given to industrial afforestation (61 per cent of the areas planted). From 1976 to 1980, a scaling back of industrial plantations, and therefore of large-scale plantations, was begun as a result of the frequently mixed results of massive plantations, the major drought and the development of more integrated and participatory approaches.

24. Despite the efforts devoted to afforestation and reforestation, the total surface area of man-made forests in tropical Africa is barely 3 million hectares, or less than the average area deforested annually, which amounts to 4.1 million hectares. In terms of increase in the average area planted annually, the campaign has been unable to narrow the enormous gap between afforestation and deforestation, the proportion of which was in the ratio of 1:29 in 1980 and 1:32 in 1990.

Reforestation campaigns in the non-tropical developing countries

25. Reported plantations accounted for 42.1 million hectares in 1990 (a surface area similar to that in the tropical countries), while the rate of annual planting amounted to 1.46 million hectares (2.61 for the tropical countries). The Asian temperate zone displayed the highest annual rate of reforestation (1.25 million hectares), whereas progress in the African subregions remains insufficient. North Africa accounts for a total of 1.79 million hectares of reforestation with an average annual rate of 72,400 hectares, while the southern

portion of the continent accounts for 1,492 hectares of plantations at an annual growth rate of 23,000 hectares of planted area. China alone accounts for 31.8 million hectares (75.5 per cent), followed by the Republic of Korea (2.1 million hectares) and Chile (1.45 hectares).

26. The average area deforested annually is 850,000 hectares, while reforested areas total 1.46 million hectares. This generally encouraging picture conceals various realities, including:

(a) The major efforts in the Asian temperate zone, with 1.25 million hectares planted annually, compared to a deforestation rate of some 400,000 hectares per year;

(b) A net loss for southern Africa, which loses 40,000 hectares of forest annually;

(c) Near-equilibrium for North Africa (deforestation: 70,800 hectares; reforestation: 72,400 hectares).

Reforestation as a response to the population's needs: Consumption of wood products

27. The urban populations of developing countries are experiencing growth on sites which are sufficiently productive. Plantations are best able to respond to the increasingly heavy demand for wood in built-up areas. The consumption of roundwood in developing countries will rise sharply in the coming years, reaching 300 million cubic metres in 2010. Between 1990 and 2010, the consumption of all wood products will require, together with other demand for such products, the establishment of between 50 and 100 million hectares of additional industrial plantations on productive sites by 2010.

28. With regard to the supply of firewood in developing countries, as early as 1981, during the preparations for the United Nations Conference on New and Renewable Sources of Energy, FAO drew attention to the energy wood crisis. A study of the problem led to findings which included the following:

(a) A firewood shortage of 972 million cubic metres by the year 2000 (500 million in Asia; 337 million in sub-Saharan and north Africa; 137 million in Latin America);

(b) A population of 2.4 billion people (including 600 million in sub-Saharan Africa and north Africa) affected by the shortage.

29. It is clear that current reforestation efforts, while praiseworthy in view of the economic situation of the developing countries and the high levels of investment which the plantations represent, fall far short of current and future needs. In the short and medium term, reforestation has little chance of replacing natural stands as a means of satisfying the growing energy needs of developing countries. It is also clear that afforestation and reforestation must be greatly accelerated and the number of plantations greatly increased through intensified forestry activities and widespread forestry management.

Reforestation as a response to environmental problems

30. With regard to the environment, it is generally recognized that reforestation plays the same roles as natural forests in contributing to the stability of the environment. Owing to the rapid deforestation of vast areas throughout the world, the role of reforestation in the protection of catchment basins and, through dune fixation, of production infrastructures, the protection of animal life, soil and water conservation, and the conservation of genetic resources and biological diversity, while difficult to quantify, is more important today than ever before.

IV. GAPS IN KNOWLEDGE AND INFORMATION

31. In the area of policies, a number of improvements are possible and, indeed, urgent.

32. Many of the shortcomings identified are due to a basic orientation towards the production of industrial wood products, which are, by their very nature, less suited to the needs of the populations of arid areas whose systems of forestry production are inseparable from other land-use systems. Among the many matters requiring further study are the following:

(a) The conversion of forest land;

(b) The practical implementation of the integration of forest plantations into agrarian systems and their effective and sustainable management;

(c) With regard to land devoted to rain-fed cultivation, the integration of forest plantations into cropland and the restoration of permanent agro-forestry park systems are of growing importance and call for the use of previously seldom-used and little-known species;

(d) Silvicultural techniques and large bodies of practical and concrete knowledge are available, even where they need improvement. However, it must be said that they are usually unknown to the general population and poorly or incompletely applied by technicians;

(e) Community and individual plantations, in addition to their role as a response to deforestation, must take into account the social consequences they entail.

33. There are numerous gaps at the research level, particularly in relation to the following topics:

(a) Conflicts and power struggles between customary law, forestry legislation, traditional land ownership, rural or land ownership codes and the administrative, traditional or religious authorities;

(b) Improvement of forest regeneration and enrichment techniques in secondary forests and improved fallow land, better knowledge of local species and methods of perfecting their artificial regeneration;

(c) Systematic research designed to achieve the optimum balance between trees, farming and cattle;

(d) Studies of the changes in soils in reforested areas and potentially beneficial effects on their productivity depending on species and plantation type;

(e) Durability and productivity of newly planted growths;

(f) Protection of the diversity of genetic stock by identifying and managing noteworthy stands, sites of origin and specimens;

(g) Greater knowledge and more focused utilization of traditional knowledge and local practices in reforesting and managing plantations.

34. We still need to identify these "local advanced technologies" and assess their performance and their advantages in comparison with modern technologies from the technical, environmental and socio-economic standpoints; if appropriate, we can then work with their originators to perfect such technologies and integrate them fully into "technical packages" for popularization purposes.

V. APPROACHES AND EXPERIENCES: SUCCESSES AND FAILURES

A. Positive experiences

35. Assessment of positive experiences should not be based merely on considerations of the scale of the achievements, but also on their significance in the countries concerned and the impetus they have provided to other experiments. The following are examples of at least partially successful experiences:

(a) Development of social forestry in Peru. This was started in 1982 as part of a project to develop community forestry on the Andes plateau;

(b) Project to rehabilitate grazing land in the south of Khorasan Province (Islamic Republic of Iran). The project, initiated in order to rehabilitate grazing lands that had been degraded by the concentration of Afghan refugees, made it possible to rehabilitate more than 20,000 hectares of badly degraded grazing lands and stabilize approximately 27,000 hectares of dunes between 1990 and 1994;

(c) Reforestation and fixation of large dunes in the Islamic Republic of Iran. For over 30 years this country has also been engaged in a number of projects designed to renew forest cover by planting, sowing and propagation. A total of 4 million hectares of arid land has been directly sown (2 million hectares) or planted and propagated (2 million hectares);

(d) Large-scale reforestation in China. The People's Republic of China has devoted significant human resources to halting deforestation and renewing

its forest cover, which is projected to increase from 14 to 17 per cent between now and 2010, reaching 20 per cent by 2050;

(e) India and reforestation. The average annual reforestation rate between 1980 and 1990 was 1.45 million hectares, of which more than 400,000 hectares per year were industrial and 1 million hectares were non-industrial reforestation;

(f) Plantations in Cape Verde. This island country of volcanic origin, whose vegetation is highly degraded as a result of over-felling and repeated droughts, has undertaken a series of reforestation initiatives since 1970 with the help of FAO, the United Nations Development Programme (UNDP) and the Government of the Kingdom of Belgium;

(g) Dune fixation in Mauritania. Based on a purely technical approach to dune fixation, planting projects initially aimed at adapting and improving biological and mechanical fixation techniques in order to protect habitat, production zones and infrastructure; the approach has gradually shifted towards the successful use of local materials and local practices;

(h) Improvement of land use in the Keita valley, Niger. An imaginative integrated rural development project is helping to restore the balance by combining traditional production systems with modern technology.

Non-forest-related advances and successes outside the scope of projects

36. In addition to the examples cited above, there have been many successful activities in rural areas arising out of spontaneous, collective or individual non-governmental initiatives. Small rural woodlands and amenity plantations which improve the village environment, line roads and demarcate the boundaries of fields are increasingly dotting the landscape in a number of Sahel countries.

B. Negative experiences

37. There are still many deficiencies and difficulties regarding plantations which demonstrate the need to improve the level of expertise and put further effort into research. All too often, officials dealing with reforestation still lack qualifications, and reforestation programmes are characterized by bad planning (in terms of programming, land use, pair matching of species and sites, etc.). The following shortcomings should be mentioned:

(a) Plantations in Africa. Planting is the preferred activity of African foresters, particularly in sub-humid to arid countries, and forestry services are often judged by the success of their plantations. However, in addition to the shortcomings described above, one of the biggest drawbacks is the limited variety of species used;

(b) Afforestation for production purposes. Industrial afforestation has too often been carried out in marginal site conditions in the form of single-species plantations extending over a large area;

(c) Reforestation versus management of natural stands in arid zones. Until recently, development projects have too often overlooked the rational utilization of natural stands and their management;

(d) Non-timber forest products. Despite their potential importance and their contribution to the local economy in tropical regions, the past 20 years have seen a sharp decline in the production of and trade in a number of non-timber forest products which used to be very important.

C. Summary of lessons learned

38. While significant progress has admittedly been made over the past decade in policies and in the legislation enacted, they still do not allow country people to organize their future with sufficient confidence and purpose; nor do they allow them to establish mechanisms for wielding the tools and investment resources that would enable them to take charge of their development.

39. International aid, and particularly official development assistance, has not always lived up to perhaps overly high expectations; it has often lacked focus, with one programme having to compete against another, and without sufficient coordination and an adequate targeting of efforts which could have ensured greater efficiency. Moreover, aid has often been allocated for relatively short periods, without any guarantee of extension. All of these factors hamper effective planning and continuity that is essential in all matters pertaining to reforestation and forestry.

40. In terms of knowledge and information, much remains to be done in the following areas:

(a) Improving training for technicians by adapting it to the conditions of their ecological, social, political and economic environment;

(b) Strengthening and improving the focus of research, which has hitherto made insufficient progress in the service of rural areas with regard to participation;

(c) Improving documentation of participation which, *mutatis mutandis*, has nevertheless made great strides in the implementation of community planting programmes;

(d) Improving documentation of the economic consequences of reforestation.

41. The involvement of non-governmental organizations in forest resource management operations over the past decade has been remarkable in the pursuit of objectives involving (a) satisfaction of household energy needs; (b) improvement of the inhabited environment; (c) the structuring of rural land occupancy and improvement of fertility; (d) in general, the campaign against land degradation and desertification. Non-governmental organizations have encouraged cooperative work.

VI. FUTURE TRENDS

A. Identification of challenges for the future

Substantial common ground coinciding with or approximating to the objectives highlighted by the forest principles 4/ and chapter 11 of Agenda 21

42. These include the following elements:

(a) Reforestation projects should be integrated into development and be planned to take account of this fact. In particular, there is a need to adopt an intersectoral approach and attack the problems of poverty and the causes of soil degradation "in the context of efficient and coherent national forestry projects and programmes";

(b) More substantial support should be provided for research. There are still many areas in which research has to provide additional tools to enhance reforestation activities, including (i) systematic evaluation of reforestation needs; (ii) better matching of the site and types of reforestation; (iii) improvement of technologies designed for arid regions, greater international scientific cooperation between the countries concerned being of particular importance; (iv) taking into account and using local knowledge and technologies.

43. Principle 9 of the Rio Declaration on Environment and Development 5/ calls for the strengthening of "endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies". This approach must be applied in its entirety, which at the same time drawing to the greatest possible extent on all technologies available locally.

Challenges in the areas of policy, strategy and legislation

44. General policy. The introduction of shrubs, bushes and trees into production systems is an important stage in maintaining or restoring the fertility of the land and remains one of the preferred tools for combating against desertification, when it is integrated into a coherent package of measures. The campaign against land degradation, in particular in arid regions, is now clearly identified with the drive against poverty and for development, the major objective being to achieve food security and ecological security. Therefore, all rural development policies must aim at solving simultaneously the three key problems of:

(a) Restoring and increasing soil fertility;

(b) Restoring herbaceous and aerial fodder; and

(c) Controlling deforestation.

45. This is, without doubt, a huge task, and it is hoped that action may be taken concomitantly on such problems as controlling population growth, stemming migration flows and transforming production systems. Accordingly, initiatives on the ground will need to be defined in terms of multisectoral development and integrated into geographical and human units, with a view to achieving a socio-economic and environmental equilibrium.

46. Role of non-governmental organizations. Despite the significant advances made, too many delays and constraints hamper the administrations and technical services of the poor countries in their attempt to generate a renewed impetus stemming from the debate on sustainable development and the programmes of Agenda 21; by combining the desire for progress felt by the communities and Governments with the potential of non-governmental organizations, many advances could be made in reforestation, which is viewed as a primary and obvious area for the involvement of non-governmental organizations.

B. Priorities

Participation, partnership with the State

47. Participation is the final phase in local populations awareness of their skills and of the fact that responsibility is shared between the State, the rural communities and the other major groups. Thus, it is a phase of partnership between equals which must be regulated within a legal, economic and ownership framework which is defined jointly on the basis of clearly set out contracts and which takes into account the need to increase the access of the greatest possible number to land and resources.

48. Therefore, States will rapidly have to improve the institutional and legal framework capable of tapping the public's commitment to reforestation, including:

(a) Increased access to land (ownership or extensive rights);

(b) Clarification of the status of new plantations;

(c) Improvement of the contractual arrangements between the State and communities regarding planting on forest land;

(d) Availability of products and assistance with their marketing, and so on.

49. Lastly, all decisions regarding afforestation and reforestation projects, particularly large-scale ones, must be taken openly and with the full participation of the groups concerned or potentially affected.

Role of pilot projects leading to wider impact

50. Pilot projects generally extend beyond the context in which they are implemented, even when they are successful in terms of achievements and innovations. It is important to analyse the factors which account for this, and

to determine clearly the socio-economic and technical objectives of pilot projects and the situations targeted, so that, in the future, they may fully perform their role in the communities they are intended to serve. Defining easily adaptable reforestation techniques matched to the skills of the local population and compatible with their social aspirations remains the chief function of pilot projects, if further progress is to be made in response to the objectives set out in Agenda 21. The results derived from such experiences will have to be carefully recorded and better presented so as to enable them to be used more widely and disseminated more rapidly.

Methods of integrating and managing afforestation and reforestation projects

51. Knowledge of the various traditional systems of agroforestry must be increased and the reasons for their success or failure analysed, in order to improve our ability to integrate and manage wooded areas within existing production systems.

Ongoing follow-up and analysis of past and future projects from a physical, economic, social and ecological standpoint: lessons learned and their application

52. It is a necessity and a top priority to help the developing countries acquire the tools needed for monitoring, ongoing follow-up, surveys and data-processing and analysis which they are unable to put in place using their own means and skills and without which there can be no planning in line with and of relevance to the socio-economic reality. It is equally important to develop appropriate tools and mechanisms for data-gathering and exchange; subregional groupings could constitute the political basis for such cooperation. It is crucial therefore to set up databases on plantations at the country level in order to compensate for the lack of knowledge on the relationship between growth and production on the one hand and on the matching of forest species to the sites involved on the other. To achieve this it is necessary to design methods of inquiry which can be used with ease by the most decentralized units and by members of the community with only limited training.

53. During the first session of the Panel, the Government of Portugal made a proposal to sponsor, jointly with a developing country to be identified, an "Expert meeting on desertification and reforestation of degraded forest lands". The expert meeting, co-sponsored by Cape Verde, will take place in Lisbon, Portugal, 24-28 June 1996. A report will be published prior to the third session of the Panel in Portuguese, English, French and Spanish. The expected results of the meeting are to:

(a) Collect and analyse the experiences of afforestation, reforestation and restoration of forest systems, especially in countries with fragile ecosystems affected by desertification and/or drought;

(b) Identify the main constraints and present the most relevant studies/cases;

(c) Contribute to the identification of practical measures and potential solutions and their impact on development and efficiency of future action.

PART TWO. IMPACT OF AIR-BORNE POLLUTANTS ON FORESTS, PARTICULARLY IN CENTRAL AND EASTERN EUROPE

I. INTRODUCTION

54. Good forest health is essential to the continuous flow of goods and services from sustainably managed forests. However forest declines and dieback of trees occur as a world-wide phenomenon. The approximate location of decline events as described in FAO's 1994 global overview of decline and dieback of trees and forests is shown in map 1.

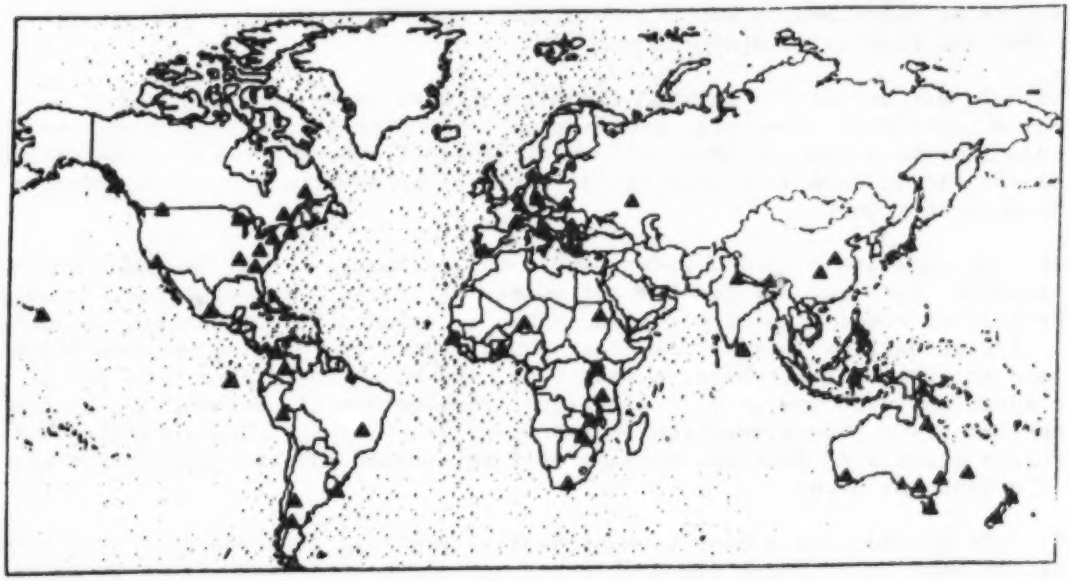
55. Forest decline is defined in this overview as an episodic event characterized by premature, progressive loss of tree and stand vigour and health over a given period without obvious evidence of a single clearly identifiable causal factor such as a physical disturbance or an attack by an aggressive disease or insect.

56. In addition to being widespread geographically, forest declines can be caused by both natural factors and human influences. Indeed forest dieback may be part of a normal ecological succession. Human activities that can contribute to forest decline include pollutant depositions, overgrazing when woodlands are used for pastoral purposes, insensitive harvesting operations, the use of plantations with low genetic diversity, the accidental introduction of pest species, fire, the alteration of hydrology and, finally, the anticipated climate change associated with the burning of fossil fuels and increased concentration of greenhouse gases.

57. In Europe, there have been historical regional declines in forest condition dating back to at least the eighteenth and nineteenth centuries. There were rarely single, undisputed causes of decline, but drought, extreme winter temperatures, late frost, insects, fungal pathogens and pollution were all suggested as important causes. Silvicultural practices, particularly clear-felling and inadequate thinning, and low potassium availability were all identified as causal factors. Arguments over which factors were primary or triggering and which were secondary go as far back as 1928.

58. In the late 1970s and early 1980s, public attention was drawn to the deterioration of forest condition in Germany and subsequently in some other European countries and parts of North America. By the early 1980s, these symptoms seemed to be widespread and public concern focused on whether such declines were new and pollutant-related. The terms "Waldsterben" and "neuartige Waldschaden" meaning "forest death" and "new-type forest decline" respectively were introduced and there was fear that the deterioration was irreversible.

59. Similarly to what happened in developed countries, the rapid economic growth now occurring in some developing countries is largely based on energy generation through the burning of fossil fuels. For example, over the last 20 years energy use in South and East Asia has doubled, and there are currently no international conventions or other instruments in place to limit emissions of acidic substances. Continued development over the next 30 years could bring a fourfold increase in emissions of sulphur dioxide in countries such as Japan, China and India.



Map 1. Approximate locations of decline events

Source: Ciesla and Donaubauer, Decline and Dieback of Trees and Forests: A Global Overview, FAO Forestry Paper, No. 120 (Rome, FAO, 1994).

60. Concerns over forest health were also being expressed in North America in the 1970s, although in the United States of America and Canada the regional diversity in the combinations of causal factors of such problems was acknowledged from the outset. Coordinated and comprehensive national and international programmes of forest monitoring and research were established to address forest health and the role of pollutant depositions in both North America and Europe.

61. The results of many of these programmes have led to a general scientific consensus on the degree to which pollutant depositions contribute to poor forest condition in Europe, a review of ongoing activities (monitoring, research and coordination), identification of gaps in understanding, provision of informed comment on the degree to which pollutant depositions threaten sustainable forest development, and consideration of possible future actions and the implications for other parts of the world.

II. CURRENT STATUS

Europe's forest resource

62. Among the 35 countries that participated the 1994 International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), 29.8 per cent of the land area is forest. Ten climatic regions have been identified covering the 35 countries that participate in the Economic Commission for Europe (ECE) and European Union (EU) surveys of forest condition.

Pollutant emissions in Europe and the European climate record

63. In parallel with silvicultural influences, pollutant emissions and depositions have been changing both qualitatively and quantitatively. European sulphur emissions have risen from under 5 million tons (of sulphur dioxide (SO_2)) in 1880 to a peak of nearly 60 million tons in 1975 with the geographical pattern of emissions (and thus of depositions) also changing substantially. By 1990, emissions had declined to about 48 million tons per year and the levels continue to fall (the data quoted above include contributions from the former Union of Soviet Socialist Republics (USSR) and Turkey). Trends are not as clear for nitrogen compounds, but emissions have also increased substantially with industrialization and the increase in road traffic.

64. Recent inventories show roughly stable levels of emission of nitrogen oxides from European countries between 1980 and 1993, and a moderate decrease in ammonia emissions from 7,649 thousand tons per annum in 1980 to 6,573 thousand tons per annum in 1993. The most recent Pan European inventory of pollutant emissions was undertaken in 1990 and emission data are now available from the European Environment Agency as CORINEAIR 1990 summary tables. These tables cover the emissions of SO_2, the oxides of nitrogen (NO_x), volatile organic compounds (NMVOC), methane (CH_4), carbon monoxide (CO), carbon dioxide (CO_2), nitrous oxide (N_2O) and ammonia (NH_3) from 29 European countries.

65. All of these pollutants and others, notably heavy metals, have the potential to influence plant growth either directly, through their effects (those which are greenhouse gases) on climate or via soil-mediated effects (for example, contamination, soil acidification, accelerated weathering and the leaching of nutrients).

66. Over the period for which instrumental records of European climate exist (about 300 years) and, indeed, within historical time, the climate record has been relatively uniform, and there have not been major shifts in vegetation cover associated with climate change.

Forest surveys and monitoring of forest conditions

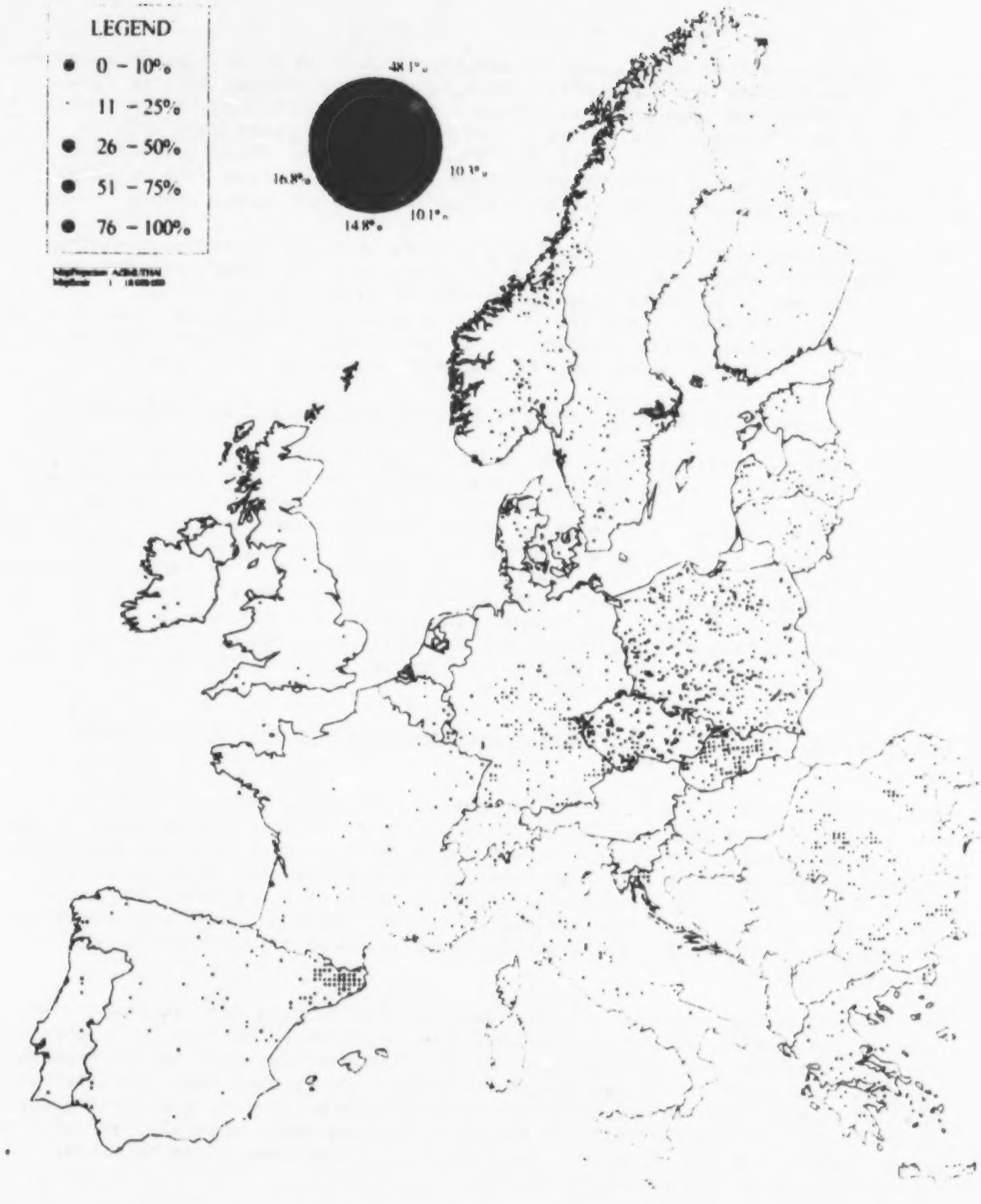
67. Because of concern over forest decline, a steadily increasing number of countries have been making annual assessments of forest condition since 1984. ICP Forests was established along with the other International Cooperative Programmes of the Working Group on Effects of the Convention on Long-range Transboundary Air Pollution which had been ratified by 39 countries in 1985 and is administered by ECE. The main activity of ICP Forests has been to coordinate forest monitoring and this has been undertaken in conjunction with the EU Standing Forestry Committee, the Working Group on Air Pollution (DG XVI) and the 15 member States. A special report on the condition of forests in Europe has been prepared as a contribution to the work of the Ad Hoc Intergovernmental Panel on Forests.

68. Within EU, forest monitoring and associated pilot and demonstration projects are under EU Council regulation (EEC) No. 3528/86 and its subsequent amendments. In 1994, 29 countries participated in these monitoring programmes and in recent years the ECE and EU have published joint annual reports on the condition of forests.

69. The annual reports of these programmes date back to 1987 and represent a thorough record of forest condition since then. However, the symptoms that are recorded are non-specific, and therefore determination of the extent to which the recorded damage is caused by pollutant depositions is not easy. A number of useful attempts have been made to address the question and it is certain that these reports present the most appropriate data from which to assess the overall damage to European forests, including that caused by pollutant depositions.

70. The percentage of trees of all species in each defoliation class is shown in map 2, which is derived from the EU/ECE source Forest Conditions in Europe: Results of the 1994 Survey. Maps of this type are available for every year from 1987 onwards and thus the reports give insight into the spatial distribution and temporal development of forest condition in Europe. The general spatial pattern as seen in map 2 is similar to that in most years of the period, although some anomalies have occurred.

71. It is clear that the Central European area that includes areas of Poland, the former German Democratic Republic (East Germany), the Czech Republic and Slovakia has the largest proportion of defoliated trees. This is the area of Europe (referred to as "the black triangle") in which there have been large



Map 2. Percentage of trees damaged in 1994

sulphur emissions from heavy industry and the combustion of high-sulphur-content coal. However there are other areas, such as parts of central Romania, the eastern Pyrenees and some plots in Norway and Sweden, with defoliation that stands out on a European scale. It is important to interpret this with reference to the national accounts in ECE and EU reports. There is no doubt that local forest-based research programmes are able to inform discussion of the extent to which pollutant depositions can be regarded as causal agents.

72. The changes over time of these data are important in determining whether long-term deterioration or improvement is occurring. The annual reports do present information on plots that are worsening, stable or improving. Unfortunately, the most recent report shows a general worsening of crown density over the period 1990-1994. A series of dry years with drought and high summer temperatures is thought to be the main cause of worsening conditions.

The International Institute for Applied Systems Analysis Forest Study 1992

73. The International Institute for Applied Systems Analysis (IIASA) has recently undertaken a study of forest resources of Western and Eastern Europe with the objectives of looking at the potential developments of the forest resource, illustrating the effects of forest decline caused by air pollutants on this resource and identifying policy options for dealing with these effects. The study represents a unique attempt to provide predictions of the way in which sulphur and nitrogen depositions might effect the development of forest resources and of wood supply in Europe. The results are of considerable interest and indicate the importance for European countries of formulating new forestry policies to deal with the new conditions caused by the decline if they are to maintain current forest resources.

Research and identification of forest declines (where and when do problems occur)

74. Over the last 20 years, there has been a substantial amount of research into the effects of pollutant depositions on trees and on the role of pollutant depositions in forest declines. Within Europe much of this work has been within national programmes such as the French Déperissement des forêts et pollution atmosphérique (Forest Decline and Atmospheric Pollution) (DEFORPA) and the Dutch Priority Programme on Acidification (DPPA). Many national programmes are now complete, with results being available in scientific journals and in programme reports.

75. In many cases, research projects have enjoyed funding from successive EU research programmes, and activities have been coordinated through EU Concerted Actions. Data are available in a series of ECE Air Pollution Research Reports. International coordination has also been carried out through the International Union of Forest Research Organizations (IUFRO), which involves a project group on The Impacts of Air Pollution on Forest Ecosystems and a special task force on Forest decline and air pollution (followed by a second task force on Forest, climate change and air pollution in 1991).

76. The overriding conclusions of the extensive research and forest studies can be considered to be:

(a) Recognition of the geographical extent over which pollutant inputs can affect forest condition (a recognition of the role of long-range transboundary air pollution);

(b) Identification of the considerable variety of stress combinations and thus forest responses that can occur;

(c) An understanding of the processes by which many of these factors influence forest condition.

77. Few of the original hypotheses that were proposed as explanations of forest decline have been rejected; however, the different factors have been put into context on the basis of their importance in particular regions. The role of virus infections, for example, has proved to be insignificant, although plant viruses might be present. In contrast, the importance of drought has become clear, with water deficit often being a major factor in the development of a decline.

78. In some regions, such as the Ore mountain of the Czech Republic and the Silesian region of Poland, the direct effects of gaseous SO_2 are a major factor. However scientific consensus now suggests that, other than in the so-called black triangle of Central Europe, the main emphasis can be placed on the soil-mediated effects of pollutant depositions (primarily sulphur and nitrogen). These have also been referred to as constituting the indirect effects of pollution in contrast to the direct effects on foliage.

79. A clear understanding of the long-term effects of continued, perhaps low, rates of sulphur and nitrogen deposition on soil condition and tree nutritional status is valuable in determining policy for pollution abatement and forest management. It has become clear that both these issues (atmospheric elemental inputs and tree nutrition) need to be addressed if forest resources are to be sustainable.

The critical loads approach

80. Based on the last 20 years of research on European forest scientific understanding has been formulated as policy through the critical loads approach. The importance of this approach has been recognized by the signatories of the current sulphur and nitrogen protocols of the 1979 Geneva Convention on Long-range Transboundary Air Pollution. The Convention was signed by all countries of Eastern and Western Europe and by Canada and the United States, and came into force in 1983. ECE was charged with supporting cooperation in air pollution control. An important activity by ECE towards achieving this aim has been the support of the Cooperative Programme for the Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP).

81. For the purposes of the nitrogen protocol (Sofia, 1988) and the second sulphur protocol (Oslo, 1994), a critical load was defined as follows: a quantitative estimate of the exposure to one or more pollutants below which significant harmful effects on specific sensitive elements of the environment do not occur according to present knowledge. The basic obligation of the second sulphur protocol is that parties shall endeavour to control emissions so that

long-term depositions do not exceed defined critical loads. A reduction in the difference between the deposition of sulphur in 1990 and critical sulphur depositions (the critical load corrected for base cation deposition and uptake) by at least 60 per cent is required. The mapping of critical loads for Europe has been undertaken by the Coordination Centre for Effects which was created by the Executive Body of the Convention. Critical loads maps have been published for the protection of aquatic ecosystems and soils (1991 and 1993). However, some countries including Switzerland and the United Kingdom have also published critical loads maps specifically for forest soils.

III. EXISTING GAPS IN KNOWLEDGE AND UNCERTAINTIES

82. A degree of scientific consensus has been reached on the question of European forest declines and this consensus view has been presented and justified here. Over the long term, continuing small inputs of sulphur and nitrogen and gaseous pollutants, such as ozone, will exert an influence on forest ecosystems. However, it is also clear that the widespread and catastrophic forest death that was feared in Europe has not occurred. Wide-scale effects of pollutant depositions are subtle and, at least in the short term, often have little commercial impact relative to the effects of extremes such as windthrow, drought and outbreaks of fungal or insect pests.

83. In managed forests, the nutritional problems that depositions create can be addressed by using fertilizers, provided that pollutant inputs are not excessive and that direct damage from pollutants in the atmosphere is not occurring. However, in the long term these responses may be difficult to maintain and the abatement of pollutant emissions is clearly the preferred option. Critical levels for forest damage have been exceeded in many areas of Europe and elsewhere in the world, and it is clear that pollutant depositions must be considered one of the abiotic factors that have a significant impact on forest ecosystems. In spite of this, the forecast or prognosis for forest condition, stability and growth remains difficult, because gaps remain in understanding the processes, and hence uncertainties are attached to even the best causal explanations of specific forest declines. In some cases, the specific gaps in understanding that remain are important in terms of current and future policy.

84. Some more general but equally important uncertainties remain that need to be addressed. These include the extent to which the critical loads approach has provided deposition targets that will effectively protect the target ecosystems, the degree to which elevated CO_2 concentrations have affected forest ecosystems and the way in which they may be affected in the future. It remains difficult to predict forest growth for a given site with confidence.

85. For European forests, many of the specific gaps in knowledge that were listed above can be addressed effectively within the structure of the level III network of forest plots, and this is an objective of ICP Forests. The entities concerned are detailed research forest plots for which the objective is to understand the processes occurring therein. Many countries have forest plots with the detailed measurements required for those plots to constitute the basis of a level II network but, in general, the full establishment of the level III network, and the effective use of the data that it is now providing, must be

seen as a priority. Data are now being submitted from the level II network and a data coordination centre is being established under the guidance of a scientific advisory panel.

86. The ongoing analysis of the level I data is also important. The indication up to 1994 of a general continuation of the worsening condition of trees throughout Europe means that it remains important to continue these monitoring activities and, in particular, to develop an understanding of the relative importance of the various factors now known to influence crown density.

87. For countries not participating in EU and ECE (Convention on Long-range Transboundary Air Pollution) coordinated activities, other, more general, gaps in knowledge may exist, as follows:

(a) The ecosystem nutrient and elemental budgets may not be known;

(b) Pollutant emission inventories may be lacking and pollutant transport patterns in the atmosphere may not be understood;

(c) Critical loads maps for forest soils may be absent;

(d) There may be no environmental monitoring system, including monitoring of forest condition.

88. Without these data, it is likely to be impossible to evaluate the extent to which pollutant depositions, forest management and other anthropogenic factors threaten forest sustainability.

IV. APPROACHES TO ADDRESSING THE ISSUE: EXPERIENCES, SUCCESSES AND FAILURES

89. In the last 20 years, a considerable amount has been learned about the status of forests in developed countries where pollutant depositions with moderate or small values (depending on one's perspective) are the norm rather than the exception. A change in the condition of the silver fir and the Norway spruce did occur in the late 1970s and early 1980s in Central Europe but it is now clear that, to a large extent, this was synchronized with a period of climatic stress. It has been suggested that interactions among the effects of climate and pollutant depositions are important. The acceleration of nitrification rates in forest soils in warm years is a good example of a mechanism that can result in such interactions.

90. The examination of changes in crown density over time supports the view that weather is an important factor in explaining year-to-year fluctuations in crown density. However, it has now been established that above certain critical values, continued pollutant depositions will result in widespread and long-term effects. The separating out of pollutant from other effects in forest ecosystems is the main challenge for the newly established level II monitoring network of EU and ECE countries.

91. The concern over a single novel forest decline throughout Europe undoubtedly resulted from the misinterpretation of the results of forest condition data (Forest Health Surveys), combined with a lack of awareness of historical records of forest declines and a lack of understanding of forest science, particularly nutrient-cycling and forest pathology. Perhaps the main lesson learned has been that the results of surveys of crown density and discoloration must be interpreted objectively. These symptoms are not specific for pollution damage. Similarly, it is misleading to place too much emphasis on temporal changes in mean values for Europe or other large and diverse geographical regions.

92. It is now clear that many of the statements that were made concerning the effects of pollutant deposition were appropriate on the local scale only. The wide-scale or overall status is assessed more clearly on the basis of the critical load exceedance and, for forests, exceedance of soil critical loads proves particularly relevant in assessing sustainability. This is because of the requirement of quantifying nutrient inputs, budgets, fluxes and outputs in the calculation of soil critical loads. A knowledge of nutrient budgets over successive rotations is also essential in determining whether the site will become impoverished as a result of forest harvesting.

93. Tree mortality and growth rates represent alternative indicators for evaluating forest condition. Neither a consideration of mortality rates nor a consideration of growth patterns supports the view that European forests are in a threatened condition, but mortality rates have been large for specific species on a local scale. Similarly, a consideration of growth patterns leads to a different view of the future.

94. Experience has been gained on the restoration of damaged forests throughout the world. Since most European forest declines are associated with nutritional disturbances, the emphasis of restoration work has been on the use of mineral fertilizers, especially magnesium (Mg) and potassium (K) salts, and the use of compensation liming. Where the nutritional imbalances have been understood correctly these techniques have proved effective. The use of dolomitic (magnesium containing) limestone in spruce forests throughout Germany is a particularly clear example of such a technique.

95. The use of more tolerant tree species where direct damage from gaseous air pollution has been a problem has also been tried. An example is the use of blue spruce (Picea pungens) in the Ore mountains of the Czech Republic. However, the fact that this approach has not been general probably reflects a preference for emission abatement as the desired course of action.

96. At least two overall and related general lessons have been learned. First, that it is important to consider sustainability in forest planning and, second, that it can be achieved if appropriate policies are adopted.

V. FUTURE TRENDS AND PERSPECTIVES: THE WAY AHEAD

97. Achieving deposition levels of less than the critical loads is clearly important if damage to forest ecosystems is to be prevented. The continued monitoring of forests is thus an important priority along with the extension of monitoring to regions not covered by effective programmes. Access to survey information and the integration of different monitoring activities are also important. These objectives can be achieved by the proper coordination of monitoring activities across the various sectors, a goal that has not always been achieved in the past.

98. It is important that in future the knowledge that has been gained in Europe and North America be put to use on a global scale in the management of pollutant emissions and forest resources. After the recognition of the transboundary nature of air pollution problems, the significance of the critical loads approach cannot be overstated. The experience of Europe has shown that this approach allows scientific understanding to be expressed quantitatively and thus to influence agreements on emission abatement.

99. Ecosystem sensitivity to acidification is affected by sulphur dioxide depositions from the burning of fossil fuel. The mapping of sensitive areas helps to develop measures to counteract potentially harmful effects of pollutant depositions. As in Europe, so in other parts of the world: a good knowledge of the location of sensitive areas and of the threshold deposition values above which damage occurs (the critical load) would allow measures to be taken before problems attained the proportions seen in some areas of Europe in the past. Initial conclusions for South and East Asia indicate the need for early action, since critical loads have probably been already exceeded in parts of Japan, China and India.

100. The sensitivity maps that are being produced for developing countries need to be developed and evaluated by local scientists who are better able to undertake this task, and the maps need to be verified using international assessment and monitoring schemes. It is also important that the general public be kept informed. Approaches and parameters developed in Europe will require modification for application in other parts of the world and local scientists are best able to formulate the needs for their countries. Technology transfer has a role but European technologies may not always be directly applicable. Liaison and cooperation are clearly important.

101. There is a clear relationship between the amount of light intercepted by forest canopies and the growth rate of the forest. This relationship forms the basis of a number of process-based growth models. It had been assumed that loss of crown density resulted in decreased growth rates; and if defoliation was severe enough and was sustained, this would certainly be the case. Indeed, a reduction in growth rate associated with loss of crown density had been an assumption of the IIASA study discussed earlier that predicted subsequent financial losses.

102. However, in recent years a number of reports of increased growth rates have been published. Possible explanations for enhanced growth are the effects of nitrogen deposition, improvements in silvicultural practice, the use of improved

plant material (selected genotypes), increases of atmospheric CO_2 concentrations and improved climate (especially temperature). It is clear from the Dutch Priority Programme on Acidification and other studies that for nitrogen depositions below a certain threshold, effects on tree growth are beneficial. This particular explanation of improving growth trends is thus well supported on a regional basis. The precise quantification and explanation of the improving growth trend on a broader basis is much more difficult to achieve and this represents one of the challenges for forestry research in the next few years.

103. European and North American research has shown that there is a strong link between pollutant depositions and sustainability: at its simplest, elemental loss or leaching from forest ecosystems, particularly of nutrient base cations which are essential for tree growth, is caused and driven by the deposition of acidic compounds. This fundamental link is quantified in the mass balance and dynamic model critical loads calculations. In Europe, the critical loads approach combined with effective forest monitoring has provided a framework for guiding international abatement commitments. Where direct damage from gaseous air pollutants to forest ecosystems has occurred locally, the required action was often obvious. On a global basis, the overriding requirement is to see that the benefits derived from the research and from the frameworks for coordination of actions are available wherever they are required.

PART THREE. ITEMS FOR DISCUSSION

104. In relation to part one of this report, the Panel may wish to consider the following items for discussion:

(a) The need for an integrated approach to reforestation and the restoration of forest ecosystems within the overall social and economic development of countries with fragile ecosystems affected by desertification and/or drought;

(b) The need to assist developing countries in increasing their capacity for continuing analysis and monitoring of past, present and future experiences, including biophysical, economic, social and ecological aspects;

(c) The strengthening for partnership arrangements among local communities, Governments, non-governmental organizations and other interested groups, including long-term institutional and legal arrangements;

(d) The establishment of a closer relationship between reforestation and management of existing forest ecosystems, including the in-depth study of traditional agrosylvopastoral systems, for the purpose of benefiting from existing knowledge and integrating management of new forests into traditional production systems.

105. Concerning part two of this report, the Panel may wish to consider the following items for discussion:

(a) The lessons to be learned from the experience of forest decline world wide and from pollutant-related declines where they have occurred;

(b) The need for national commitments and international agreements on pollutant emissions for countries not within the Convention on Long-range Transboundary Air Pollution;

(c) The link between pollutant and elemental inputs from the atmosphere and sustainability and the extent to which pollutant depositions (and aerial elemental inputs, rates of mineral weathering and elemental losses from leaching by ground- and surface water and in forest harvesting) are considered in forest planning and management;

(d) The need for continuation in EU and ECE countries, and for geographical expansion, of monitoring programmes where required;

(e) The need to develop the use of the critical loads approach within the context of sustainability world wide;

(f) The coordination of these activities, the dissemination of information to the public and the access of potential users (managers and policy makers) to data;

(g) Specific research and field data collection to support the above-mentioned activities, including work on ecosystem function where pollutant depositions threaten sustainability.

Notes

1/ See Official Records of the Economic and Social Council, 1995, Supplement No. 12 (E/1995/32), chap. I, annex I, sect. III (I.4).

2/ See document E/CN.17/IPF/1995/3, sect. II, para. 18 (I.4).

3/ See Report of the United Nations Conference on Environment and Development, vol. I, Resolutions Adopted by the Conference (United Nations publication, Sales No. E.93.I.8 and corrigendum), resolution 1, annex II, para. 11.10.

4/ Ibid., annex III.

5/ Ibid., annex I.

Map 3. Location of the European sites mentioned in the text